Observations and Modeling for Source Characterization

Mark A. Moline
Center for Coastal Marine Sciences and
Biological Sciences Department
California Polytechnic State University
1 Grand Ave.
San Luis Obispo, CA 93407
Phone: (805) 756-2948 Fax: (805) 756-1419 Email: moline@marine.calpoly.edu

Lyle F. Hibler
Pacific Northwest National Laboratory
1529 West Sequim Bay Road
Sequim, WA 98382
Phone: (360) 681-3616 Fax: (360) 681-3699 Email: lyle.hibler@pnl.gov

Grant Number: N00014-08-1-0508

LONG-TERM GOALS

We propose to continue our work coupling Unmanned Underwater Vehicle (UUV) and other coastal observations with a 3D hydrodynamic model (Delft3d-FLOW) to investigate circulation and transport of coastal source material. While coastal areas near riverine discharge have traditionally been difficult to sample, UUVs with advanced sensor technology afford the opportunity to systematically study the dynamic components of these systems. Highly resolved measurements of circulation patterns, in water components, bottom topography and characterization will be coupled with the modeling effort. This combination will allow UUV guidance and improve model performance. It is hoped that the integration of mobile systems for localized modeling will be a 'system' that is portable to other systems to help advance our understanding of circulation patterns and mechanisms for change in bottom topography and morphology.

OBJECTIVES

The primary goal of this study is to develop a high resolution predictive capability of sources and their advective transport within the Gulf of Catalina and along the shoreline of San Diego County. This will be achieved using a combination of in situ observations and a 3D hydrodynamic model (Delft3d-FLOW). Source characterization will be conducted using a number of UUVs equipped with appropriate sensors. These sources include riverine inputs from the Tijuana River and two outfall plumes in the region. The UUVs will also observe the behavior of these sources in space and time. Data from UUV platforms and other components of an observatory network in the area will populate the model for initialization, evaluation and optimization of predicting the advective flow of these sources of interest. The interaction between model and observational assets will continue throughout the program ensuring optimization as well as providing guidance for UUV mission planning. The model will also include a watershed module with the intention of better quantifying riverine inputs into the local area.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 2008	**Annual**	**00-00-2008 to 00-00-2008**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Observations And Modeling For Source Characterization	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
California Polytechnic State University,Center for Coastal Marine Sciences and Biological Sciences Department,1 Grand Ave.,San Luis Obispo,CA,93407	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
code 1 only

14. ABSTRACT

We propose to continue our work coupling Unmanned Underwater Vehicle (UUV) and other coastal observations with a 3D hydrodynamic model (Delft3d-FLOW) to investigate circulation and transport of coastal source material. While coastal areas near riverine discharge have traditionally been difficult to sample, UUVs with advanced sensor technology afford the opportunity to systematically study the dynamic components of these systems. Highly resolved measurements of circulation patterns, in water components, bottom topography and characterization will be coupled with the modeling effort. This combination will allow UUV guidance and improve model performance. It is hoped that the integration of mobile systems for localized modeling will be a ?system? that is portable to other systems to help advance our understanding of circulation patterns and mechanisms for change in bottom topography and morphology.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**4**	

APPROACH

Delft Model. A three-dimensional circulation and transport model Delft3D will be used in this study to predict the advective transport of sources within the study area in Southern California. Tidal, wind-driven and density-driven circulation will be accounted for in the model. The effects of bathymetry, earth's rotation and bed stress are also included. The model is based on the continuity equation and horizontal momentum equation and uses a turbulence closure submodel to adjust mixing rates as function of flow conditions. The model domain is represented by an orthogonal curvilinear mesh in the horizontal and a terrain following ($\sigma-$) coordinate system in the vertical. The model numerics are fully documented in WL Delft Hydraulics (2003) and it has been used to conduct various modeling studies (*i.e.* Hesselink *et al.* 2003; Bielecka and Kazmierski 2003). The model mesh will be developed based the best bathymetry information available that provide comprehensive coverage within the study area. In addition, higher resolution meshes will be developed to best resolve source points of interest. For example, the Tijuana River mouth, two outfall locations as well as beach locations of interest to ONR. The circulation within the finer resolution model will driven by flow (tidal elevations or currents) provided by the coarse model results. The tidal elevation conditions along all open boundaries will be set to available tidal predictions from NOAA (http://tidesonline.nos.noaa.gov/geographic.html) or Xtide (Flater 2006). The number of vertical layers will be determined based on the resolution required and computational considerations.

Environmental Observations with UUVs. As part of this project, observational data sets on regional and local fine scales will be collected by REMUS UUVs. Cal Poly owns and operates two REMUS vehicles with 3,300 km of underwater time and over 170 missions. These deployments have included similar to the AOI for this study; river plumes, surf zone transition areas, dye plumes and outfall plumes. For a description of the vehicles and their applications see Moline *et al.* (2005, 2007). The sensor suite on these vehicles will be used to characterize various sources in the region and track their behavior in time and space. These data will be integrated with the model for improved parameterization of the model and predictive power (see Hibler et al., 2008).

WORK COMPLETED

Development of a preliminary model of a portion of the southern coast of California adjacent to the Tijuana River and San Diego Harbor. An initial model was developed for the area of interest. An example particle cloud is shown in Figure 1 below. Initial testing of the model indicated a need for mesh adjustment and identified data gaps.

Model consultation with UCSD/SIO. Provided consultation to Dr. Eric Terrill's team at Scripps Institution of Oceanography (SIO) on the use of the Delft3d-FLOW. Dr. Terrill's team provided observational dataset necessary for model development. These datasets included bathymetry and hydrography.

UUV demonstrations. As part of other DOD projects, the UUV has been run successfully over 350km since June, 2008 on long duration (11 hours) missions launched and recovered from nearshore locations. This approach will be used in providing boundary conditions for the modeling to be conducted during the initiation of the wet season in Southern California. See http://www.marine.calpoly.edu/auv/REMUS/index.php

Project Meeting in San Diego in September 2007. Attended project planning meeting with project participants from ONR, CalPoly, DELFT and SIO.

RESULTS

From the initial model mesh developed for the area of interest, an illustration of a preliminary model run of a particle field from the Tijuana River during a rain event.

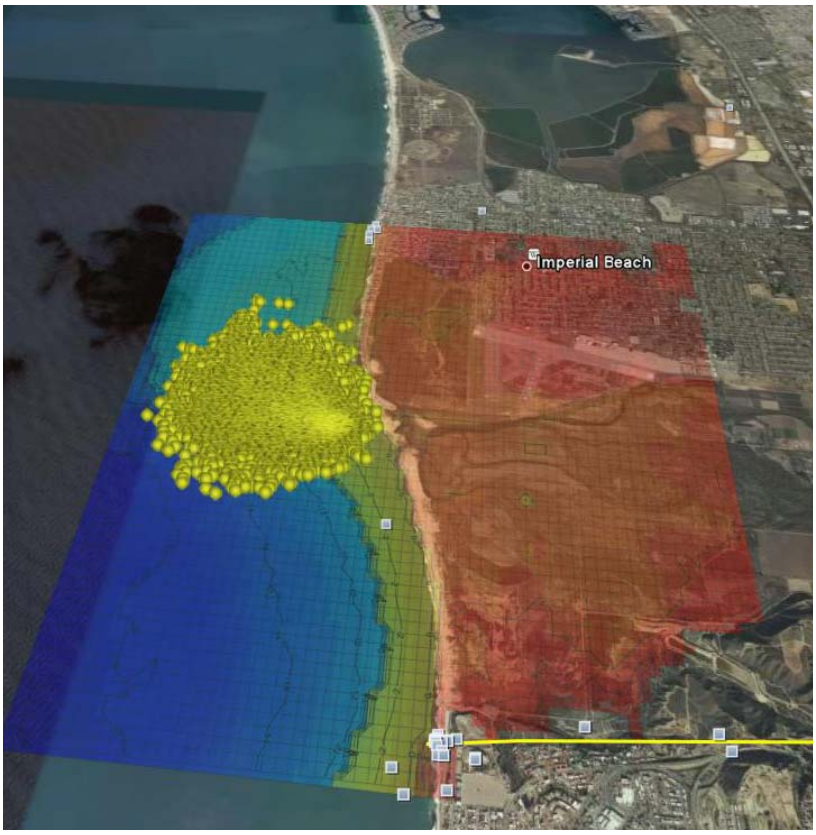

Figure 1. Simulated particle cloud near Tijuana River mouth under vertically mixed, tide-only conditions. A portion of the bathymetry used for the model configuration is shown for the area near the Tijuana River.

IMPACT/APPLICATIONS

We are in the preliminary stages of this project and will provide impacts of the work and application as the project develops.

RELATED PROJECTS

This collaboration originated from work done in ONR's Coastal Environmental Effects program (N00014-06-2-0105) and a data-model re-analysis program (N00014-07-1-1113).

REFERENCES

Bielecka, M., and Kazmierski, J. (2003). "A 3D mathematical model of Vistula Lagoon hydrodynamics—general assumptions and results of preliminary calculations," Diffuse Pollution Conference Dublin 2003.

Flater, D. (2006). "XTide version 2.8.2," http://www.flaterco.com/xtide, harmonicsdwf-2006-07-08.

Hesselink, A. W., Stelling, G. S., Kwad¼k, J. C. J., and Middelkoop, H. (2003). "Inundation of a Dutch river polder, sensitivity analysis of a physically based inundation model using historic data," Water Resources Research, 39(9), 1–1–1–17.

Hibler LF, AR Maxwell, LM Miller, NP Kohn, DL Woodruff, M. J. Montes, J. H. Bowles and M. A. Moline. (2008). Improved fine scale transport model performance using AUV and HSI feedback in a tidally dominated system. J. Geophys. Res., 113, C08036, doi:10.1029/2008JC004739.

Moline, M. A., Blackwell, S. M., Allen, B., Austin, T., Forrester, N., Goldsborogh, R., Purcell, M., Stokey, R. and C. von Alt. (2005). Remote Environmental Monitoring UnitS: An Autonomous Vehicle for Characterizing Coastal Environments. J. Atmos. Oceanic. Technol., 22 (11): 1798–1809.

Moline, M.A., D.L. Woodruff and N.R. Evans. (2007). Optical Delineation of Benthic Habitat Using an Autonomous Underwater Vehicle. J. Field Robotics. 24 (6): 461-471. doi: 10.1002/rob.20176.

PUBLICATIONS

Hibler LF, AR Maxwell, LM Miller, NP Kohn, DL Woodruff, M. J. Montes, J. H. Bowles and M. A. Moline. (2008). Improved fine scale transport model performance using AUV and HSI feedback in a tidally dominated system. J. Geophys. Res., 113, C08036, doi:10.1029/2008JC004739. [published, refereed]

Chao, Y., J. D. Farrara, Z. Li, O. Schofield and M. A. Moline. (2008). On the Impact of Autonomous Underwater Vehicles on Coastal Ocean Monitoring and Forecasting. Limnol. Oceano., 53: 2251-2263. [published, refereed]

Dickey, T. D., E. C. Itsweire, M. A. Moline, and M. J. Perry. (2008). Introduction to the Limnology and Oceanography Special Issue on Autonomous and Lagrangian Platforms and Sensors (ALPS). Limnol. Oceano., 53: 2251-2263. [published, refereed]

HONORS/AWARDS/PRIZES

Mark A. Moline, named lifetime Fellow of the California Council on Science and Technology